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PHYTOTOXICOLOGY SURVEY

INVESTIGATION:

LIBBEY ST. CLAIR LIMITED

WALLACEBURG (1995)

SEPTEMBER 1998

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PHYTOTOXICOLOGY SURVEY INVESTIGATION:

LIBBEY ST. CLAIR LIMITED

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Report No: SDB-040-3511-96

BACKGROUND and INTRODUCTION

Libbey-St.Clair is a glass manufacturing company located in a mixed industrial/residential area on Forhan Street South in Wallaceburg. The Phytotoxicology Section has conducted investigations of vegetation damage and foliar chemistry in the vicinity of the facility since 1976 (except 1988, 1990, 1991, 1993 and 1994). In each of these years, maple tree (Manitoba, Norway and/or silver maple) foliage was examined for contaminant-induced injury and analyzed chemically. Abatement activities have apparently been successful in reducing the emissions of fluoride and chromium. However, the facility continues to emit boron during the production of borosilicate glass.

From 1976 to 1984, no injury associated with boron accumulation was observed on sensitive vegetation such as Norway maple. In 1985, boron-induced injury was first observed on Norway maple located immediately south of the facility. In 1986 and 1987, boron-type injury was observed at 2 locations near the plant. The injury consisted of intercostal and/or marginal necrosis on up to 10% of the surface of affected leaves. Confirmed boron injury was only observed at one site in 1989 (Site 10). Boron-like injury was observed at 4 locations in 1992 and, as in earlier years, was the most severe at Site 10.

In 1995, the Sarnia District Office requested the assistance of the Phytotoxicology Section, Standards Development Branch, in the investigation of Libbey-St.Clair because of the suspected continuation of boron emissions. This report summarizes the results of sampling conducted in 1995.

METHODOLOGY

Foliage assessments and collections in the vicinity of Libbey-St.Clair were conducted by Craig Kinch, Phytotoxicology Scientist. The 12 sampling locations established in previous surveys (see Figure 1) were examined for boron-induced injury and sampled for chemical analysis on August 24, 1995. Foliage samples were collected in duplicate and stored in plastic bags during transport to the Phytotoxicology processing lab. Samples were oven-dried, ground in a Wiley-mill and stored in glass bottles. Processed samples were submitted to the MOEE laboratory in Etobicoke for total boron [B] analysis.

Wind data normals were obtained from the closest Environment Canada monitoring station (Sarnia - approximately 8 km NE of the centre of Sarnia) for the period from 1967 to 1980.

RESULTS and DISCUSSION

Annual wind normals are illustrated in Figure 2. This data indicates a strong tendency toward winds from the S (S and SSW) and from the W (W and WSW).

Foliar injury was observed at 5 locations. As in 1989 and 1992, the most severe boron-like injury was found at Site 10 (300 m north). This injury consisted of intercostal and marginal discolouration, flecking and/or necrosis of affected leaves. At Site 10, Norway maple leaves were the most affected with up to 15% mostly terminal necrosis affecting up to 60% of the tree's foliage. Unlike 1992, there was no corresponding injury on Manitoba maple at the same site. Foliar injury was also absent on silver maple at Site 10. Some minor boron-like injury was also found on Manitoba maple at Site 15 (260 m west of Libbey-St.Clair) with less than 1% mostly terminal necrosis on approximately 5% of the foliage in the canopy. Injury at Site 1 (240 m south of Libbey-St.Clair) was confined to Norway maple with a maximum of 1-3% terminal necrosis on up to 90% of the crown foliage. Up to 5% tip necrosis was also observed on up to 5% of canopy foliage on silver maple foliage at Site 5. Boron-like injury was also found on Manitoba maple at Site 3 (780 m south of Libbey-St.Clair) with approximately 1% mostly terminal necrosis on approximately 15% of the foliage in the canopy.

The analytical results for total acid-extractable concentrations of boron in foliage are presented in the attached table. The Phytotoxicology ULN guideline for boron is 175 µg/g. The ULN is the arithmetic mean plus three standard deviations of the mean of boron in foliage collected from sites away from known point sources of boron pollution. There is a high probability that concentrations in foliage exceeding the ULN are above background and therefore the result of contamination from a pollution source. Concentrations exceeding the ULN are, however, not necessarily toxic to plants, animals or people.

The ULN for boron was exceeded at 6 sites in 1995, up from 2 sites in 1992. As in 1992, the concentrations of B exceeded the ULN guideline for tree foliage at Site 1. In addition, the guideline for B was exceeded at Site 2, Site 3, Site 5, Site 7 and Site 10. In all cases where there was an exceedence of the ULN, the concentrations of B were higher in 1995 than 1992. The average B concentration for all sites was 149 µg/g in 1995 compared to 96 µg/g in 1992. This data reverses the trend towards continued reductions in foliar boron concentrations in the vicinity of Libbey St. Clair.

Exceedences of the ULN were found at sites to the N, NE, E and also to the S. Higher concentrations to the N and E are consistent with the prevailing wind directions. However, it has been over 10 years since B concentrations at Site 7, located 700 m E of the facility, have exceeded the ULN.

Particularly surprising were exceedences of the ULN to the S, especially at Site 3, some 780 m from the facility. The mean concentration of B in Manitoba maple at this site (590 µg/g - replicate concentrations of 540 and 640 µg/g) was amongst the highest found for any species of maple since 1982. Similarly, the mean concentration of B in silver maple at Site 3 (285 µg/g - replicate concentrations of 310 and 260 µg/g) was amongst the highest concentration found in silver maple in the 1995 survey year. Sites 1 and 2 to the S also exceeded the ULN for B. There are at least 3 possible explanations for exceedences to the S. Firstly, it may be that winds from the north were either more prominent than usual in this survey year or happened to occur during high emissions from the plant. This would not, however, explain why concentrations of B at Site 3, distant from the facility to the south, were higher than concentrations at sites closer to the facility. Secondly, it is possible that there is another new source of B contributing to gradients in the area that may explain the exceedences at Site 3. A recent moss bag study conducted from October to December, 1994 to address releases from foundries just to the SW of Libbey St.Clair included analysis for B [Phytotoxicology Survey Report: Moss Bag Survey in the Vicinity of Benn Iron / Eaton Yale, Wallaceburg (1994) - SDB-016-3511-95]. The study did find elevated boron concentrations to the north of the foundries that were attributed to Libbey St. Clair (Figure 3). However, the data would not support the contention that, for at least those 3 months in 1994, a industrial source of B was operating that would explain elevated concentrations south of Libbey St.Clair. Finally, it is possible that site specific factors unknown to the investigator (eg. boron contaminated fill) were operating at Site 3 that would explain the elevated boron concentrations.

Generally, Manitoba maple had the highest foliar boron concentrations followed by Norway maple and silver maple, respectively. As in earlier years, Norway maple had the most characteristic and severe boron-like injury. Even when foliar boron concentrations were relatively high (example Site 3), silver and Manitoba maple displayed few if any foliar symptoms of injury. This illustrates the variation in air pollution sensitivity that is commom between plant species.

A three-site mean (Sites 5, 10 and 15) has been used in previous reports to track the general pattern of boron uptake in maples close to the facility. These sites were chosen because they are the closest sites and because boron injury has occurred consistently. In every year of the survey up to 1989 this three-site mean exceeded the ULN guideline for boron. However, similar to 1992, the three-site mean in 1995 was 157. This would appear to be attributable to a substantial reduction in B concentrations in Manitoba maple foliage at Site 15. This pattern is not consistent with the overall trend towards higher B concentrations described above.

SUMMARY and CONCLUSIONS

On average, mean foliar boron concentrations around Libbey-St.Clair were markedly higher in 1995 than in 1992. The ULN for boron was exceeded at 6 Sites in 1995 compared to 2 exceedences in 1992. The average B concentration for all sites was 149 µg/g in 1995 compared to 96 µg/g, marking a departure from a downward trend in foliar boron concentrations noted in 1992. Elevated B concentrations to the N and E were consistent with the prevailing wind directions although they extended further to the E than in previous years. Particularly surprising were exceedences of the ULN to the S, especially at Site 3, some 780 m from the facility. Concentrations at this site could not be explained with existing data for the area. Subsequent environmental monitoring around Libbey-St.Clair should include soil sampling and analysis of total hot water extractable boron. These data are necessary in order to determine if the tree injury is caused by historical soil contamination or ambient air emissions and may help to explain high concentrations in maple foliage at Site 3.

Figure 1: Phytotoxicology Surveillance Sites in the Vicinity of Libbey-St.Clair, Wallaceburg.

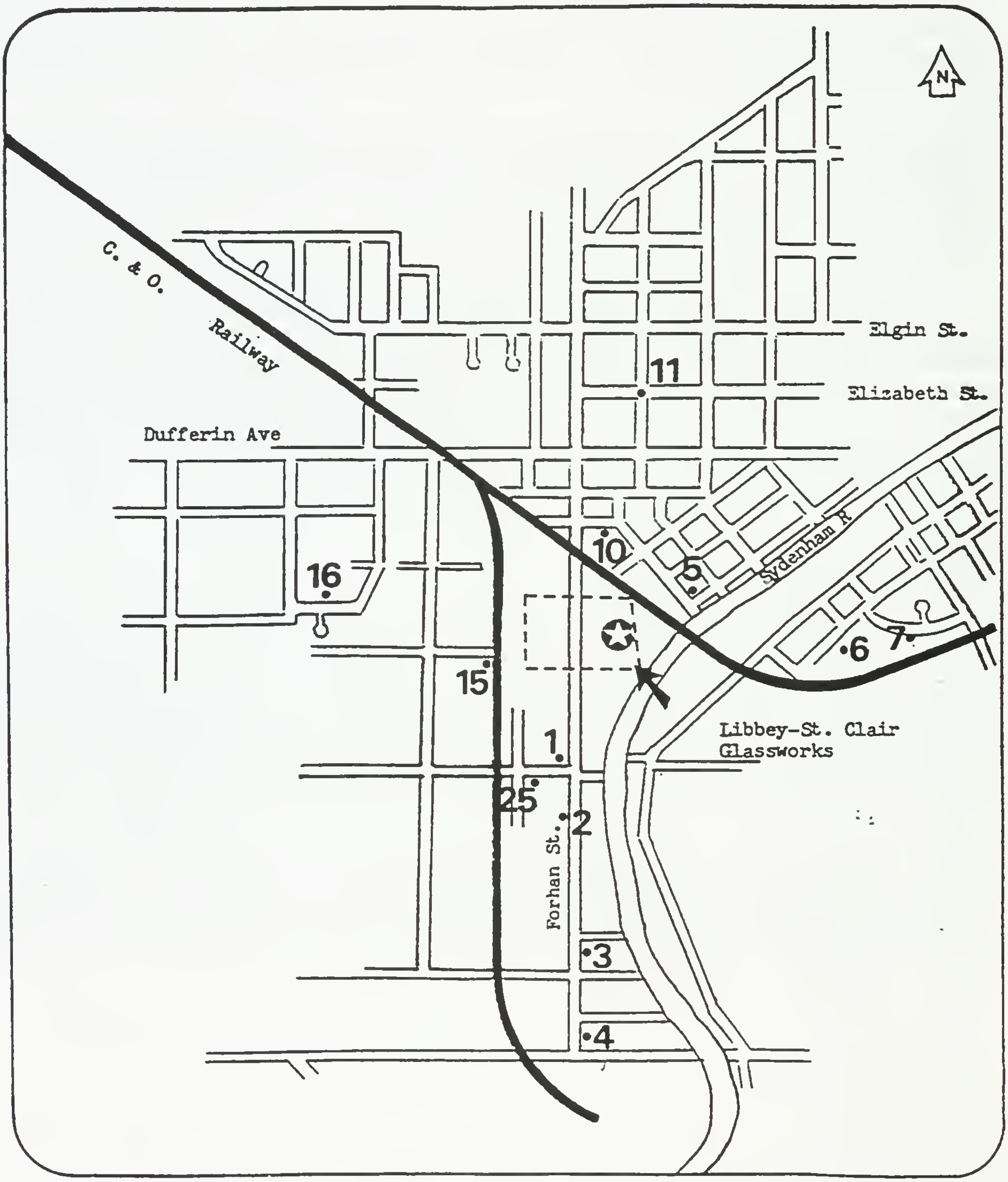


Figure 2: Annual Wind Direction Normals for the Sarnia Airport (1967-1980).

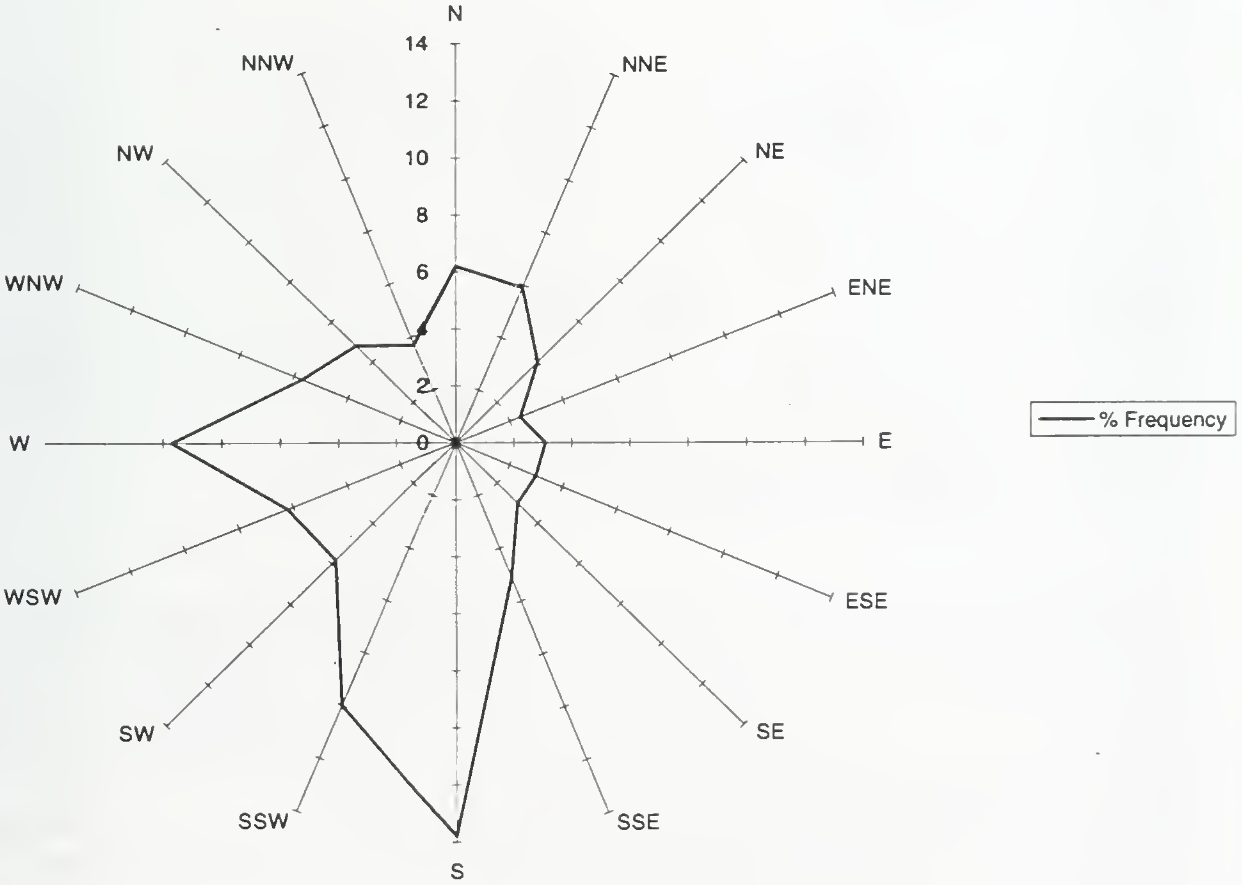
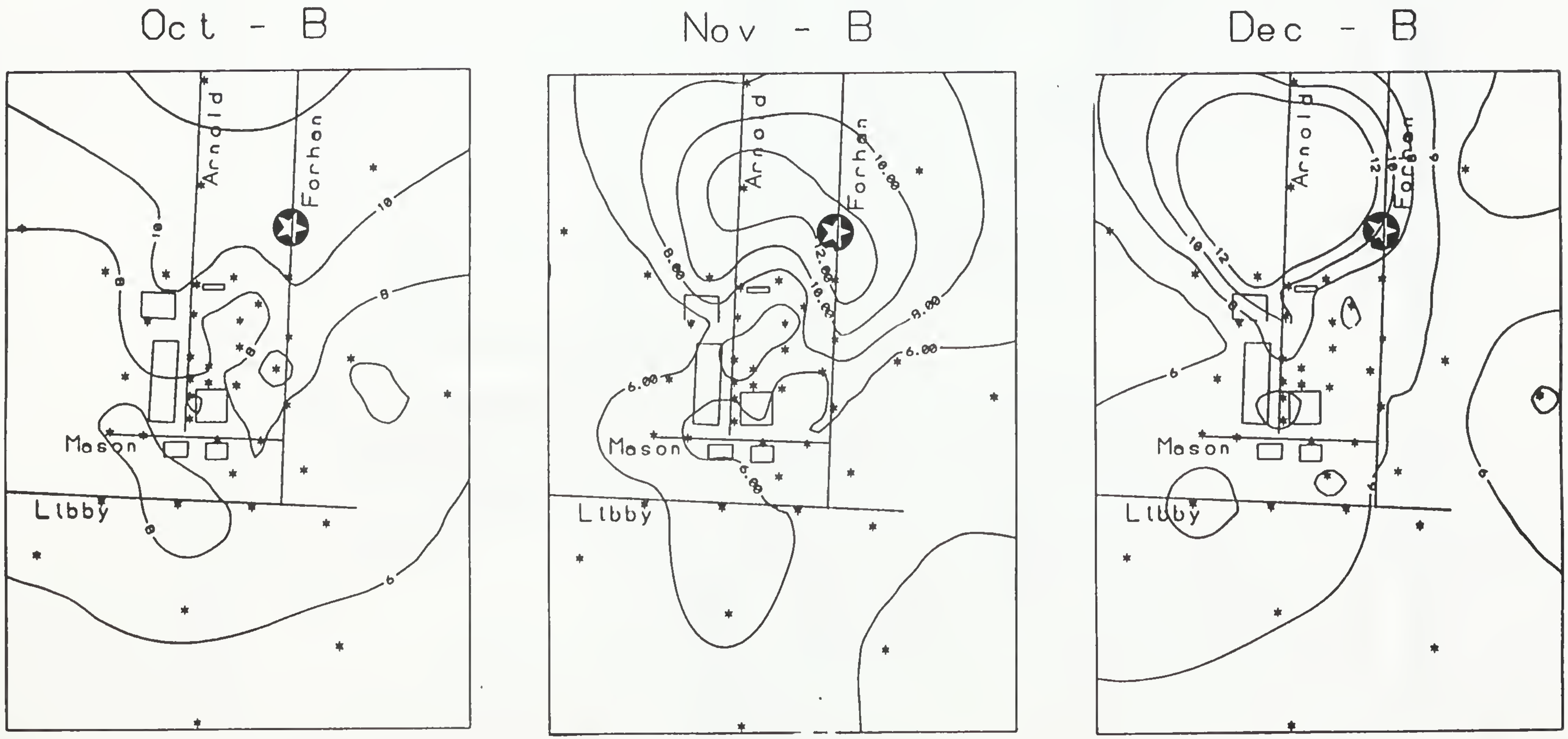


Figure 3: Concentration Contour Maps of Boron in Moss Bags collected in the Vicinity of Mason and Arnold Streets, Wallaceburg (October to December, 1994) [Phytotoxicology Survey Report: Moss Bag Survey in the Vicinity of Benn Iron / Eaton Yale, Wallaceburg (1994) - SDB-016-3511-95]. Libbey St.Clair is identified by the circle star.



Mean* Boron Concentrations in Tree Foliage in the Vicinity of Libbey-St.Clair, Wallaceburg - August 1995.

Site	Species	Distance and Direction from Glassworks	Boron Concentrations (1982-1995) (µg/g - dry weight)								
			1982	1983	1984	1985	1986	1987	1989	1992	1995
1	Mm	240 m S	NA	NA	NA	NA	NA	NA	56	54	74
	Nm		170	**203**	**720**	**435**	**296**	**185**	NA	**180**	**195**
2	Sm	475 m S	175	103	96	92	121	100	78	72	105
	Mm		135	140	120	145	**181**	165	**185**	120	**215**
3	Sm	780 m S	160	147	155	140	164	NA	110	175	**285**
	Mm		NA	NA	NA	NA	NA	45	**245**	135	**590**
4	Sm	960 m S	105	117	**195**	90	54	105	49	38	48
	Mm		140	127	**210**	125	135	**200**	78	76	89
5	Sm	180 m E	175	**183**	**180**	145	**183**	**195**	145	155	**205**
6	Sm	470 m E	65	71	66	41	66	85	83	44	82
	Mm		140	90	97	105	68	135	89	68	130
7	Sm	700 m E	80	111	**195**	125	76	115	59	67	**185**
	Mm		90	113	110	75	107	125	125	84	125
10	Sm	300 m N	130	130	135	115	144	140	115	85	100
	Mm		**450**	137	**320**	**215**	**229**	**255**	**190**	115	**220**
	Nm		125	**193**	145	150	**219**	155	**195**	150	135
11	Sm	560 m N	50	65	64	67	72	71	75	40	65
	Mm		105	107	72	52	81	84	71	63	105
15	Mm	260 m W	**420**	**627**	125	**430**	**682**	**470**	**240**	**250**	125
16	Sm	680 m W	40	38	36	29	28	36	29	18	38
25	Sm	350 m S	NA	NA	NA	NA	NA	NA	25	32	55
	Mm		**185**	170	**200**	135	125	**210**	**190**	85	100
Three Site Mean (5, 10 & 15)			**260**	**254**	**181**	**211**	**291**	**243**	**177**	151	157
ULN			175								

ULN	Phytotoxicology Upper Limit of Normal (ULN) guideline for urban soils, see attached appendix.
*	Mean of duplicate samples, all units in u/g.
NA	Not available.
Note:	Shaded data exceed ULN Guideline.

Sm - Silver maple; Mm - Manitoba maple; Nm - Norway maple

APPENDIX I

Derivation and Significance of the MOEE Phytotoxicology "Upper Limits of Normal" Contaminant Guidelines

The MOEE Upper Limits of Normal (ULN) contaminant guidelines represent the expected maximum concentration in surface soil, foliage (trees and shrubs), grass, moss bags, and snow from areas in Ontario not exposed to the influence of a point source of pollution. Urban ULN guidelines are based on samples collected from developed urban centres, whereas rural ULN guidelines were developed from non-urbanized areas. Samples were collected by Phytotoxicology staff using standard sampling procedures (ref: Ontario Ministry of the Environment 1983, *Phytotoxicology Field Investigation Manual*). Chemical analyses were conducted by the MOEE Laboratory Services Branch.

The ULN is the arithmetic mean, plus three standard deviations of the mean, of the suitable background data. This represents 99% of the sample population. This means that for every 100 samples which have not been exposed to a point source of pollution, 99 will fall within the ULN.

The ULN do not represent maximum desirable or allowable limits. Rather, they are an indication that concentrations that exceed the ULN may be the result of contamination from a pollution source. Concentrations that exceed the ULN are not necessarily toxic to plants, animals, or people. Concentrations that are below the ULN are not known to be toxic.

ULN are not available for all elements. This is because some elements have a very large range in the natural environment and the ULN, calculated as the mean plus three standard deviations, would be unrealistically high. Also, for some elements, insufficient background data is available to confidently calculate ULN. The MOEE Phytotoxicology ULN are constantly being reviewed as the background environmental data base is expanded. This will result in more ULN being established and may amend existing ULN.